Measurement of the spin-lattice ...

relaxation is now being studied by the method of continual saturation and by the pulse method. Fig. 1 shows a block diagram of the spectroscope with which the spin-lattice relaxation time was measured by the pulse method. The klystron K_1 with a sequence frequency of 100-0.1 cps furnished pulses of 25 μsec duration with an efficiency of 1.5 w, the klystron K_2 operated at 9400 Mc/sec. Fig. 2 shows an oscillogram of the relaxation curve of the Fe^{3+} ions. The spin-lattice relaxation time was for both concentrations at 4.2°K equal $T_1 = (4.9 \pm 0.4) \cdot 10^{-4}$ sec, the spin-spin relaxation times were $1.4 \cdot 10^{-8}$ and $0.66 \cdot 10^{-8}$ sec, respectively. By the method of continual saturation, the same values were obtained for both concentrations at 2.1°K: $T_1 = (1.6 \pm 0.2) \cdot 10^{-2}$ sec. From the data the conclusion is drawn that at helium temperatures, the spin-lattice relaxation does not depend on concentration, and is inversely proportional to the fifth power. The strong temperature dependence indicates that at helium temperatures, processes of second order play the main part. For the purpose of confirming the temperature dependence law, the line width at 0.2% concentration was measured within the range of 4.2-40°K and it was found that the T^{-5}-law holds up to about 40°K: $T_1 = 0.64\ T^{-5}$ sec. Provisional studies (by the pulse method)

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of the cross relaxation of the lines of the two non-equivalent ions produced no result, which is ascribed to the short cross relaxation time. Thereupon, the problem was studied whether a cross relaxation exists at all in the given case; the specimens used for this purpose had a Fe^{3+} ion concentration of 0.46%. It was found that a strong cross relaxation exists between the lines of the two magnetically non-equivalent ions. Also the relaxation processes in $K_3Cr(CN)_6$ with a Cr^{3+} concentration of 0.24% were studied. The relaxation curves at 4.2 and 2.1°K turned out to be representable by the sum of two exponents with highly deviating characteristic times: the time of the one exponent was temperature-independent and equal to $4.5 \cdot 10^{-4}$ sec, that of the other was proportional to temperature and at 4.2°K equaled $1.9 \cdot 10^{-3}$ sec, so that also in this case the existence of a cross relaxation was proven. The authors finally thank R. P. Bashuk and A. S. Bebchuk for placing the crystals at their disposal. There are 2 figures and 8 references: 2 Soviet-bloc and 7 non-Soviet-bloc.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences USSR)

ZVEREV, G.M.; PROKHOROV, A.M.

Electron paramagnetic resonance of the V^{3+} ion in corundum. Zhur. eksp. i teor. fiz. 40 no.4:1016-1018 Ap '61. (MIRA 14:7)

1. Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.

(Paramagnetic resonance and relaxation)
(Corundum--Electric properties)

S/056/61/040/005/011/019
B111/B205

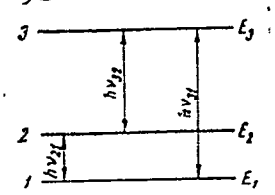
9, 4170 (1051, 1482)

AUTHOR: Prokhorov, A. M.

TITLE: Quantum counters

PERICDICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 5, 1961, 1384-1386

TEXT: The sensitivity of receivers for long-wave radiation can be improved by conversion of quanta into visible or ultraviolet light. Incident radiation of frequency ν_{21} with auxiliary radiation of frequency ν_{32} may give rise to quanta $h\nu_{31}$ with $\nu_{31} > \nu_{32} > \nu_{21}$ (see Fig.).



The numbers of particles in the energy states E_1 and E_3 were calculated by virtue of the transition probabilities with and without an external field. Thus, the author obtained

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S/056/61/040/005/011/019
B111/B205

Quantum counters

$$n_1 = Ae^{a_1 t} + Be^{a_2 t} + n_1^0,$$

$$n_3 = A\frac{a_1 - a_{11}}{a_{12}}e^{a_1 t} + B\frac{a_2 - a_{11}}{a_{12}}e^{a_2 t} + n_3^0, \qquad (2),$$

where

$$a_{1,2} = \tfrac{1}{2}(a_{11} + a_{22}) \pm \left[\tfrac{1}{4}(a_{11} - a_{22})^2 + a_{12}a_{21}\right]^{1/2},$$

$$n_1^0 = [1 + a_{22}(w_{12} + W_{12})/(a_{11}a_{22} - a_{12}a_{21})]\, n,$$

$$n_3^0 = -a_{21}(w_{12} + W_{12})\, n / (a_{11}a_{22} - a_{12}a_{21}). \qquad (3)$$

and

$$a_{11} = -2W_{12} - w_{12} - w_{21}, \quad a_{12} = w_{31} - w_{21} - W_{12},$$
$$a_{22} = -2W_{32} - w_{31} - w_{32}, \quad a_{21} = -W_{32}. \qquad (I)$$

(n_i - number of particles in the i-th state; n - total number; w_{ik} and W_{ik}-

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Quantum counters

transition probabilities with and without radiation, respectively.) For steady states one has $n_3^0 = (w_{12}+W_{12})n/w_{31}$ on the condition that $w_{12}, w_{21}, W_{12} \ll w_{31} \ll W_{32}$; $w_{32} \ll W_{32}$ and $w_{13} = w_{23} = 0$. The number of quanta spontaneously emitted from E_3 to E_1 is given by $N = n_3^0 w_{31} = (w_{12} + W_{12})n$. Even without radiation, a "dark" background of radiation $N_d = n_0 w_{12}$ with quantum emission is left over. The sensitivity of the receiver reaches a maximum when $nw_{12} \approx N_{min}$, where N_{min} is the least number of transitions that can be recorded. Considering the fact that the quanta $h\nu_{21}$ are practically all absorbed, one finds $n = Shc\,\Delta\nu/8\pi^2 \cdot \nu_{21} |A_{12}|^2$, where $\Delta\nu$ is the line width, A_{12} the element of the transition matrix, and S the surface area of the specimen. In deriving n, it was assumed that the specimen is penetrated once by the radiation. However, if the radiation is reflected from the specimen, the expression for n is to be multiplied by a factor $(1-k)$, where k is the reflection factor. The derivation

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Quantum counters

was performed with the use of a formula from Ref. 2 (A. M. Prokhorov, ZhETF, 34, 1658, 1958). Assuming that $W_{23} = 0$ and $T_1 = 1/(w_{12} + w_{21})$, w_{12} can be written as $w_{12} = T_1^{-1} \exp(-h\nu_{21}/kT)$ where T_1 stands for the relaxation time. In order to have the least possible value of w_{12} so that $nw_{12} \ll N_{min}$, temperature must be sufficiently low. If $w_{21} \ll W_{12}$, N will be proportional to the signal strength. If $W_{32} \gg w_{31}, w_{32}$, the relaxation time, τ, is equal to $2/w_{31}$ with τ being always greater than the lifetime in the excited state. There are 1 figure and 2 references: 1 Soviet-bloc and 1 non-Soviet-bloc.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva, Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev, Academy of Sciences USSR)

SUBMITTED: December 1, 1960

Card 4/4

25184
S/056/61/040/006/005/031
B102/B214

24,7900

AUTHORS: Korniyenko, L. S., Prokhorov, A. M.

TITLE: Electron paramagnetic resonance of the Fe^{3+} ion in corundum

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1594 - 1601

TEXT: The authors of this paper discovered the paramagnetic resonance spectrum of the Fe^{3+} ions in corundum in 1957 (ZhETF, 33, 805, 1957), and later showed that this makes corundum a suitable material for the manufacture of paramagnetic amplifiers (ZhETF, 36, 919, 1959). In this connection, more accurate studies of the electron paramagnetic resonance (e.p.r.) of iron ions in corundum have now been carried out. e.p.r. spectra are very precisely measured for the cases of normal and parallel orientation of the trigonal axis of the crystal with respect to the external magnetic field at frequencies of $(9 - 10)\cdot 10^9$ cps, and temperatures of 290, 77, 4.2, and 2°K. The values of the constants of the spin-Hamil-

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tonian at various temperatures could be determined from these measurements. Direct measurements of the initial energy splittings of the ground state levels (for zero magnetic field) were also made at 290, and 4.2°K, and the spin-lattice relaxation time T_1 at 4.2°K was determined.

The concentrations of the paramagnetic ions in the samples studied amounted to 0.02 and 0.002%. As was shown in a previous paper, the e. p. r. spectrum of the Fe^{3+} ions can be explained by means of the spin-Hamiltonian

$$\hat{\mathcal{H}} = g\beta H\hat{S} + D[\hat{S}_z^2 - \tfrac{1}{3}S(S+1)] + \tfrac{1}{6}a[\hat{S}_\xi^4 + \hat{S}_\eta^4 + \hat{S}_\zeta^4 - \tfrac{1}{5}S(S+1)(3S^2 + 3S - 1)] + \tfrac{1}{180}F[35\hat{S}_z^4 - 30S(S+1)\hat{S}_z^2 + 25\hat{S}_z^2 - 6S(S+1) + 3S^2(S+1)^2], \quad (1)$$

(g is the spectroscopic splitting factor when the splitting is assumed to be isotropic, β is the Bohr magneton, $\hat{S}$ is the electron spin operator,

Electron paramagnetic resonance ...

$\hat{S}_i$ are the operators of the projections to the corresponding axes with the eigenvalue S = 5/2, a is the cubic crystal field constant, and D and F are the trigonal crystal field constant). The coordinates ξ, η, ζ correspond to the cubic axes, and z corresponds to the trigonal one (which coincides with the [111] direction in the system ξ, η, ζ). The Euler angles for the transition from one system of coordinates to the other are determined, dimensionless coefficients are introduced, and the diagonal matrix for the operator S_z of the system of ions Fe^{3+} and Al^{3+} is given. The cases of parallel and perpendicular orientation of $\vec{H}$ are separately discussed. Table 1 gives the experimental results for parallel orientation and Fe^{3+} concentration of 0.02%. For this concentration, the half widths of the 1st, 4th, and 5th lines were equal to 10±2 oe and were dependent on the temperature; for the 2nd and 3rd they were strongly frequency dependent and lay between 20 and 30 oe. A comparison of the measurements at 2 and 4.2°K showed no difference in the values of the constants of the spin-Hamiltonian. Measurements of the e.p.r. spectrum were also made for parallel orientation at 290°K and a paramagnetic ion concentration of 0.002%. It was found from these measurements that the

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Electron paramagnetic resonance ....

possible divergences of the spin-Hamiltonian constants from the values given in Table 2 lie within the experimental error. It is seen that the constants D, a-F, and |a| increase at the same rate with decreasing temperature, while g remains practically constant. The results are in good agreement with those of Bogle and Simmons except for |a|.

Table 2

Constants	Values of the constants of the spin-Hamiltonian for the Fe^{3+} ion in corundum		
	290°K	77°K	4.2°K
g	2.0030±0.0006	2.0032±0.0007	2.0029±0.0007
D, oe	+1796.4±0.4	+1836.2±0.6	+1838.5±0.6
a - F, oe	+ 353.2±0.4	+362.6±0.5	+ 362.7±0.5
a , oe	248.7±1.0	254.1±1.3	253.5±1.3

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Electron paramagnetic resonance ...

The experimentally observed spectrum for perpendicular orientation can also be described by the Hamiltonian (1) and the constants from Table 2 (for parallel orientation!). The energy level difference corresponding to the resonance transitions can be calculated from that experimental value of the resonance field. A comparison of experimental and theoretical results is made in Table 3. Direct measurements of the primary splittings (ground state (^6S) spin doublet) at 290 and 4.2°K gave the following values:

	$T = 290°$ K	$T = 4.2°$ K
Δ_1, *мгц*:	11768±4 (11759 ±6)	12046±13 (12044±6)
Δ_2, *мгц*:	18873±11 (18866±6)	19298± 3 (19291±6),

Δ_1 is the energy difference between the middle and the lower doublet, and Δ_2 that between the upper and the middle doublet (in Mc/sec). The values in parentheses have been calculated with the help of the constants of the

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Electron paramagnetic resonance ...

spin-Hamiltonian at h=0 according to the equation

$$\Delta_{2,1} = \left[3D + \frac{1}{6}(a - F)^2 + \frac{20}{9}a^2 \pm \left(D - \frac{3}{2}(a - F)\right)\right].$$

τ_1-measurement gave for a Fe^{3+} concentration of 0.002% the value of $(12\pm1)\cdot10^{-3}$ sec, and for a Fe^{3+} concentration of 0.02% the value of $(8\pm1)\cdot10^{-3}$ sec. The authors thank R. P. Bashuk, and A. S. Bebchuk for supplying the samples; G. A. Feshchenko (deceased) for discussions; and V. A. Kozlov, and N. G. Slovetskaya for help in measurements. V. M. Vinokurov, M. M. Zaripov, and N. R. Yafayev are mentioned. There are 3 figures, 23 tables, and 10 references: 3 Soviet-bloc and 7 non-Soviet-bloc. The most important references to English-language publications read as follows: M. H. L. Pryce. Phys. Rev. 80, 1107, 1950; M. J. D. Powell et al. Phys. Rev. Lett., 5, 145, 1960; G. S. Bogle, H. F. Simmons. Proc. Phys. Soc. 73, 531, 1959.

ASSOCIATION: Institut yadernoy fiziki Moskovskogo gosudarstvennogo uni-

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Electron paramagnetic resonance ...

versiteta (Institute of Nuclear Physics of Moscow State University)

SUBMITTED: January 4, 1961

Legend to Table 1: 1) temperature, 2) frequency in Mc/sec, 3) resonance values of the magnetic field (in oe) corresponding to the given transitions.

Температура, °К (1)	Частота, мгц (2)	Резонансные значения магнитного поля (Oe), соответствующие различным переходам (3)				
		3 ⟷ 2	2 ⟷ 4	2 ⟷ 4	2 ⟷ 3	1 ⟷ 2
290	9641,7	752,5	3489,3	3595,6	7624,8	10147,2
		(752,5) *	(3490,5)	(3595,3)	(7624,6)	(10146,8)
77	9838,4	778,8	3589,3	3658,5	7789,9	10363,1
		(778,7)	(3587,7)	(3657,8)	(7789,7)	(10363,0)
4,2	9846,8	779,4	3592,8	3663,0	7798,0	10375,5
		(779,8)	(3592,5)	(3662,5)	(7798,0)	(10375,7)

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25186
S/056/61/040/006/007/031
B102/B214

24.7900

AUTHORS: Manenkov, A. A., Prokhorov, A. M.

TITLE: Paramagnetic resonance of Mn^{2+} in SrS

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40 no. 6, 1961, 1606 - 1609

TEXT: The known fact that the ground state (^6S) of the Mn^{2+} ion with zero orbital momentum suffers no splitting in the first approximation due to the crystal electric field, and that experimentally, however, in many crystals even large splitting is observed (which is attributed to an admixture of higher states to ^6S) were the reasons for undertaking fresh investigations of the behavior of this ion in the crystal field. The authors investigated the paramagnetic resonance of Mn^{2+} in the crystal field of SrS which crystallizes in the cubic form. The samples were polycrystalline and contained about 0.05 % Mn^{2+} ions. The measurements were made at room temperature, and at the temperature of liquid nitrogen

Paramagnetic resonance of....

for ν = 9300 Mc/sec. The spectrum observed at both temperatures consisted of six groups of hyperfine-structure lines corresponding to the nuclear spin of Mn^{55} : I = 5/2. The general character of the spectrum at 300 and 77° K was the same. However, a closing together of the lines and a small increase in the hyperfine-structure constant was observed on transition to 77° K. The observed spectrum is described by the spin-Hamiltonian:

$$\hat{\mathcal{H}} = g\beta \mathrm{H}\hat{\mathrm{S}} + A\hat{\mathrm{S}}\hat{\mathrm{I}} + \tfrac{1}{6}a\left[\hat{S}_x^4 + \hat{S}_y^4 + \hat{S}_z^4 - \tfrac{1}{5}S(S+1)(3S^2-1)\right], \quad (1)$$

The first term therein describes the interaction between the electron spin $\vec{S}$ and the external magnetic field $\vec{H}$, the second term gives the interaction between $\vec{S}$ and the Mn^{55} nuclear spin $\vec{I}$, and the third term that between $\vec{S}$ and the cubic crystal field. A perturbation - theoretical calculation taking into account terms of the third order with respect to

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the hyperfine interaction, and terms of the first order with respect to the constant of the cubic crystal field gives for the magnetic field strength at which the absorption line corresponding to the transition M - M - 1 is observable:

$$H = H_0 - Am - \frac{A^2}{2H_0}\{I(I+1) - m^2 + m(2M-1)\} +$$
$$+ \frac{A^2}{4H_0}\{[S(S+1) - M(M+1) + 2M(m-M)][I(I+1) - m(m-1)] -$$
$$- [S(S+1) - M(M-1) + 2(M-1)(m-M+2)] \times$$
$$\times [I(I+1) - m(m+1)]\} + F(a, M), \qquad (2)$$

Here $H_0 = h\nu/g\beta$, and $F(a,M) = \begin{cases} 0 \text{ for the transition } M = 1/2 \rightarrow -1/2 \\ \pm 5/2pa \text{ for transitions } M = \pm 3/2 \rightarrow \pm 1/2 \\ \mp 2pa \text{ for transitions } M = \pm 5/2 \rightarrow \pm 3/2 \end{cases}$

Paramagnetic resonance of....

$p = 1 - 5\Phi$, $\Phi = l^2m^2+l^2n^2+m^2n^2$. l, m, n are the direction cosines of the angle which the magnetic field makes with the cubic crystal axes. As is evident from it, the displacements of the second and the third order in the hyperfine structure depend on the electronic transitions, and the magnitude of the splitting increases with increasing m . For the two outermost groups of lines ($m=\pm 5/2$) all the five lines are well resolved. The comparison of the observed spectrum with the formula (2) gives the following expression for the constants of the Hamiltonian:

$$g = 2{,}0009 \pm 0{,}0005, \quad A = (75{,}4 \pm 0{,}2)\cdot 10^{-4}\,см^{-1}, \quad a < 1{,}4\cdot 10^{-4}\,см^{-1} \quad \text{for } T = 300^\circ\ \text{K};$$

$$g = 2{,}0010 \pm 0{,}0005, \quad A = (77{,}0 \pm 0{,}2)\cdot 10^{-4}\,см^{-1}, \quad a < 1{,}2\cdot 10^{-4}\,см^{-1} \quad \text{for } T = 77^\circ\ \text{K}.$$

In the case of the best resolution ($m=5/2$) the line width of the transition is: $M = 1/2 \rightarrow -1/2$ 2.8 G (300°K) and 1.9 G (77°K) for the transitions $M = \pm 3/2 \rightarrow \pm 1/2$ and $M = \pm 5/2 \rightarrow \pm 3/2$ 5.6 G (300°K) and 4.3 G (77°K).

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S/056/61/040/006/007/031
B102/B214

Paramagnetic resonance of....

The constant of the cubic field (a) was determined from the anisotropic broadening of the lines $M = \pm 3/2 \rightarrow \pm 1/2$, $\Delta H_a \sim 5/2 \Delta pa$. g and A are determined by a comparison of the position of the lines $M = 1/2 \rightarrow -1/2$ having the minimum width with the formula (2). The spin-lattice relaxation time was estimated from the dispersion of the lines $M = 1/2 \rightarrow -1/2$ at room temperature, and at 77°K, the value found being $5 \cdot 10^{-8}$ sec. The contribution of the spin-lattice interaction to the line-width is negligible. The intensity ratio of the lines $M = \pm 5/2 \rightarrow \pm 3/2$, $M = \pm 3/2 \rightarrow \pm 1/2$, $M = 1/2 \rightarrow -1/2$ agrees well with the theoretical result: 5 : 8 : 9 : 8 : 5 if the line-width is taken into account. The hyperfine structure constant A for Mn^{2+} in SrS is considerably smaller than that for Mn^{2+} in CaF_2.

This is related to the covalent character of the Mn^{2+} binding in SrS. There are 2 figures and 5 non-Soviet-bloc references. The most important references to English-language publications read as follows: R. Stahl-Brada, W. Low. Phys. Rev. 116, 561, 1959; W. Low, U. Rosenberger. Phys. Rev. 116, 621, 1959; H. Watanabe Progr. Theor. Phys. 18, 405, 1957.

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25186
S/056/61/040/006/007/031
B102/B214

Paramagnetic resonance of...

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences, USSR)

SUBMITTED: January 4, 1961

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END

PROKHOROV, Aleksandr Mikhaylovich; KONYUKOV, V. K.

"Some properties of Quantum Optical Generator Radiation"

Paper presented at Optical Society of America Meeting, Washington, D. C.
14-17 March 62

MANENKOV, A. A.; PROKHOROV, A. M.

"On the Temperature dependence of the spin-lattice relaxation times in crystals."
Report presented at the First InternationalConference on Paramagnetic Resonance, Jerusalem, Israel, 16-20 July 1962

33363
S/181/62/004/001/039/052
B104/B112

24.7900 (1055, 1144, 1163)

AUTHORS: Konyukhov, V. K., Pashinin, P. P., and Prokhorov, A. M.

TITLE: Study of the paramagnetic electron resonance and the optical spectrum of the Yb^{3+} ion in CdF_2

PERIODICAL: Fizika tverdogo tela, v. 4, no. 1, 1962, 246 - 248

TEXT: The paramagnetic electron resonance spectrum was observed at three frequencies in the centimeter and millimeter wave ranges. The spin-lattice relaxation time was measured at helium temperature. The Yb concentrations in CdF_2 single crystals reached 0.1% by weight. Two lines of the transition $^2F_{7/2} \rightarrow {}^2F_{5/2}$ were detected in the far infrared of the Yb^{3+} absorption spectrum at 0.961 and 0.972 μ. The splitting of the ground state was estimated from changes in the g-factor of the spectroscopic splitting. The distance between the lowest ground state Γ_7 and the next level Γ_8 of the ground state was 21.1 ± 0.4 cm^{-1}. The spin-lattice relaxation time T_1 in

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the range of helium temperatures is inversely proportional to the temperature: $T_1 = \frac{(6.7 \pm 0.7)}{T} 10^{-4}$ sec. As this result was obtained by two different techniques (pulse technique and method of continuous saturation), a two-level system was assumed. L. M. Belyayev, Kh. S. Bagdasarov, and V. Ya. Khaimov-Mal'kov are thanked for having grown the single crystals. There are 5 references: 2 Soviet and 3 non-Soviet. The three references to English-language publications read as follows: W. Low. Phys. Rev., 118, 1603, 1960; Phys. Rev., 109, 265, 1958; C. Kittel, J. M. Luttinger. Phys. Rev., 73, 162, 1948.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR Moskva
(Physics Institute imeni P. N. Lebedev, AS USSR, Moscow)

SUBMITTED: August 23, 1961

34230

S/181/62/004/002/013/051
B102/B138

24.7900 (1055, 1144, 1163)

AUTHORS: Manenkov, A. A., Milyayev, V. A., and Prokhorov, A. M.

TITLE: Relaxation times of Cr^{3+} and Fe^{3+} ions in rutile single crystals

PERIODICAL: Fizika tverdogo tela, v. 4, no. 2, 1962, 388 - 391

TEXT: The pulse saturation method (9400 Mc) was used to study spin-lattice relaxation for Cr^{3+} and Fe^{3+} ions in rutile at liquid-helium temperatures. The paramagnetic resonance lines were saturated with pulse durations between 100 and 0.01 msec, in order to find the reason for the existence of spin-spin cross relaxation effects. With no cross relaxation, the curves describe spin-lattice relaxation only and are independent of pulse duration. The single crystals investigated were grown by the Verneuil method. In all experiments crystal orientation was such that the external magnetic field was perpendicular to the c-axis and coincided with one of the a-axes. With saturation pulses of 100-50 msec the relaxation curves of rutile with Cr^{3+} impurity were found to consist of two components:

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Relaxation times of Cr^{3+} and Fe^{3+}... S/181/62/004/002/013/051 B102/B138

$I(t) - I_o = A_1 e^{-t/T_1} + A_2 e^{-t/T_1'}$; $A_1 + A_2 = -I_o$, where I(t) is the line intensity at a moment of time t after the end of the pulse, I_o - equilibrium line intensity. The following spin-lattice relaxation times were calculated for the Cr^{3+} ions:

Transition	4.2°K			1.7°K		
	T_1 msec	T_1' msec	A_1/I_o %	T_1 msec	T_1' msec	A_1/I_o, %
1 ⟷ 2	4	1.1	38	9	2.8	60
3' ⟷ 4'	2.3	0.5	13	3.3	0.8	30
3 ⟷ 4	2.2	0.5	24	3.3	1	60

The weak temperature dependence of the transitions 3⟷4 and 3'⟷4' can be explained if the lower levels 1,2 and 1',2' take part in these transitions. For the 1⟷2 transition cross-relaxation was observed with pulses of 0.05 msec duration. In this case, besides T_1 and T_1', the relaxation curve also

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Relaxation times of Cr^{3+} and Fe^{3+}...

contains a "fast" exponent $T_{12} \ll T_1, T_1'$. For Fe^{3+} relaxation was studied on several paramagnetic resonance lines for [110], between 1000 and 3500 oe. The relaxation times for the lines observed were similar and ~2 msec. T_1 and T_1' were between 3.5 and 6, and 0.6 and 2.5 msec. Cross relaxation was also observed with short pulses. R. P. Bashuk and A. S. Bebchuk were thanked for the preparation of the rutile single crystals. There are 3 figures, 1 table, and 5 references: 1 Soviet and 4 non-Soviet. The four references to English-language publications read as follows: H. J. Gerritsen et al. Phys. Rev. Lett. 2, 153, 1959; H. J. Gerritsen et al. J. Appl. Phys., 31, 1566, 1960; A. Okaya et al. Bull. Am. Phys. Soc. 5, 73, 1960; J. H. Van Vleck. Phys. Rev. 57, 426, 1940; J. H. Pace et al. Proc. Phys. Soc. B77, 257, 1961.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR Moskva
(Physics Institute imeni P. N. Lebedev AS USSR, Moscow)

SUBMITTED: August 14, 1961

Card 3/3

34231
S/181/62/004/002/014/051
B102/B138

24,7900 (1055,1144,1163)

AUTHORS: Zverev, G. M., Korniyenko, L. S., Prokhorov, A. M., and Smirnov, A. I.

TITLE: Electron paramagnetic resonance and spin-lattice relaxation of the Er^{3+} ion in a CdF_2 single crystal

PERIODICAL: Fizika tverdogo tela, v. 4, no. 2, 1962, 392-395

TEXT: Er^{3+} was introduced as an isomorphic impurity into CdF_2, in which the fluor ions form a cubic lattice, the Cd ions being in the centers of cubes formed by the anions. The Er^{3+} ions replace Cd ions. The e. p. r. measurements were made at 4.2°K, with several different frequencies and for an Er^{3+} concentration of 0.1%. The following spectrum parameters were determined:

Card 1/3

Electron paramagnetic resonance and ...

ν, Mc/sec	g	A, oe
9500	6.758 ± 0.010	73.0 ± 1.0
25800	6.745 ± 0.005	-
72000	6.735 ± 0.005	73.9 ± 1.0

The frequency dependence of the g-factor is due to the contributions of the wave functions of the excited states. The field-induced change of the g-factor can be determined by using perturbation theory:

$$g = g_0 \left[1 - \frac{\Lambda^2 \beta^2 H^2}{\delta^2} \left| \langle 1 \left| \hat{J}_z \right| 2 \rangle \right|^2 \right]$$

IX

g_0 is the g-factor at H=0, Λ - Landé factor, δ is the mean distance to the nearest upper level of the state group (2): $\left\{ \pm \frac{13}{2}, \pm \frac{5}{2}, \pm \frac{3}{2}, \pm \frac{11}{2} \right\}$

Card 2/4

Electron paramagnetic resonance and ...

$\langle 1|$ and $|2\rangle$ denote the ground and excited states. $A = (2.31 \pm 0.03) \cdot 10^{-2} cm^{-1}$. Spin-lattice relaxation was studied by the continuous saturation method and by the pulse method with 3.2 cm waves. The temperature dependence of relaxation time τ_1 was determined by several methods, e. g. between 16 and 18°K from epr line broadening. Though S. A. Al'tshuler has developed a theory of spin-lattice relaxation of rare-earth ions, (ZhETF, 24, 691, 1953), the experimental results for Dy^{3+} ions in a cubic lattice can only be explained qualitatively. At $T < 4.2^{\circ}K$, $\tau_1 \sim T^{-1}$, at higher temperatures the course of $\tau_1(T)$ cannot be described by an exponential law of the $\tau_1 \sim T^{-n}$ type. This is due to anomalies caused by other bi- and trivalent ions. L. M. Belyayev, Kh. S. Bagdasarov and V. Ya. Khaimov-Mal'kov and P. P. Pashinin are thanked for help. There are 1 figure, 1 table, and 13 references: 5 Soviet and 8 non-Soviet. The four most recent references to English-language publications read as follows: M. Dvir, W. Low. Proc. Phys. Soc., 75, 139, 1960; W. Low. Paramagnetic Resonance in Solids. p. 130. New York - London.

Card 3/4

34231
S/181/62/004/012/[illegible]
B102/B138

Electron paramagnetic resonance and ...

1960; C. B. P. Finn et al. Proc. Phys. Soc., B77, 261, 1961; J. M. Baker et al. Proc. Phys. Soc. B73, 942, 1959.

ASSOCIATION. Moskovskiy gosudarstvennyy universitet im. M. V. Lomonosova (Moscow State University imeni M. V. Lomonosov)

SUBMITTED. August 14, 1961

Fig. Time dependence of τ_1 for Er^{3+}.

Card 4/4

ZVEREV, G.M.; PROKHOROV, A.M.; SHEVCHENKO, A.K.

Mechanism underlying the effect of a vanadium admixture on the spin-lattice relaxation of chromium in corundum. Fiz. tver. tela 4 no.11:3136-3143 N '62. (MIRA 15:12)

1. Moskovskiy gosudarstvennyy universitet imeni M.V. Lomonosova.
(Paramagnetic resonance and relaxation)
(Nuclear spin)

S/109/62/007/002/016/024
D256/D303

AUTHORS: Karlov, N.V., and Prokhorov, A.M.

TITLE: Sensitivity of quantum receivers of electromagnetic radiation

PERIODICAL: Radiotekhnika i elektronika, v. 7, no. 2, 1962, 328 - 331

TEXT: The following properties of quantum amplifiers and counters are discussed: 1) The set noise of the devices according to the received frequency range for monochromatic as well as continuous radiation; 2) The role of the external thermal radiation. Here the spectral density of the noise at the input and the resulting power of the noise at the output are considered in dependence upon the pass-band of the amplifier, and expression for the minimum detectable spectrum density are given for continuous as well as monochromatic radiations. It is pointed out that mono-chromatic radiation detection became important in connection with the recent developments of quantum light-generators; 3) A quantum amplifier is compa-

Card 1/2

red with a bolometer showing that for monochromatic radiation the sensitivity of the quantum amplifier may exceed that of the bolometer in the case of a very low background; 4) The optical and infrared region amplifiers are considered. The method proposed by J. Weber (Ref. 3: Phys. Rev., 1957, 108, 3, 537) for the infrared region is discussed followed by a consideration of paramagnetic crystals for use as quantum counters; 5) Expressions are presented for the minimum number of signal photons detectable with a counter in the presence of background, as well as the corresponding spectral densities, for both thermal radiation and monochromatic signal detection. The sensitivity of the counters is shown to be higher than that of the amplifiers; 6) The derivation of the counter sensitivity is presented in the Appendix; the fluctuations of the instantaneous intensity of light are taken into account. There are 6 references: 2 Soviet-bloc and 4 non-Soviet-bloc. The references to the English-language publications read as follows: J.A. Giordmaine et al., Proc. I.R.E., 1959, 47, 6, 1062; L. Mandel, Proc. Phys. Soc., 1958, 72, 468, pt. 6, 1037; J. Weber, Phys. Rev., 1957, 108, 3, 537.

ASSOCIATION: Fizicheskiy institut im. P.N. Lebedeva AN SSSR (Institute of Physics im. Lebedev, AS USSR)

SUBMITTED: June 21, 1961

Card 2/

33995
S/056/62/042/001/009/048
B125/B108

24.7900 (1055, 1144, 1163)

AUTHORS: Korniyenko, L. S., Pashinin, P. P., Prokhorov, A. M.

TITLE: The spin-lattice relaxation time of the Ti^{3+} ion in corundum

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 1, 1962, 65 - 66

TEXT: The time of spin-lattice relaxation of the Ti^{3+} ion in corundum was measured with the method of pulsed saturation at liquid helium temperatures by means of an apparatus described by P. P. Pashinin and A. M. Prokhorov (ZhETF, 40, 49, 1961). Earlier estimates by L. S. Korniyenko, A. M. Prokhorov (ZhETF, 38, 1651, 1960) have yielded a general form of the temperature dependence of τ_1. A saturating pulse of 10 - 20 microseconds with a peak power of ~1 watt produced at 2°K a sharp sag in the epr line. The external magnetic field was parallel to the trigonal axis of the crystal. By applying the saturating pulses every four modulation (50 cps) periods of the magnetic field it was possible to observe the behavior of the sag in the line between two successive pulses. The first epr line corresponds to the application of the saturating pulse.

Card 1/3

The sag of the paramagnetic line observed at the subsequent passages of the magnetic field through resonance is less than 5 oersteds wide. Its depth decreases with the characteristic time $\tau = (5 \pm 1) \cdot 10^{-2}$ sec. If the width of the sag remains constant during observation, τ is simply the time τ_1 of spin-lattice relaxation. $\tau_1 > \tau$ in the case that the sag width decreases (not observed in the present experiments) owing to cross relaxation within the line. No sag in the line was observed at 4.2°K since the saturation power was too low. The appearance of a sag in the epr line at 2°K under the action of a brief saturating pulse may be explained as follows: If the Ti^{3+} ion arrives exactly at the place of the Al^{3+} ion in the lattice, $g_\perp$ and the intensity of epr lines become zero when the external magnetic field is parallel to the trigonal axis of the crystal. With randomly distributed Ti^{3+} ions, the values of $g_\perp$ for the individual ions are different from zero, and the resulting non-zero contribution to the epr line is the greater the more the position of the Ti^{3+} ion departs from the corresponding zero value of $g_\perp$. Because of the random distribution of the ions in the crystal, ions with similar

g-factors may be far from one another, which renders their cross-relaxation interaction difficult. On the other hand, this interaction is very weak within the line owing to the small value of $g_{\perp}$. R. P. Bashuk and A. S. Bebchuk are thanked for having prepared the samples, and G. M. Zverev for discussions. There are 1 figure and 2 Soviet references.

ASSOCIATION: Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta (Institute of Nuclear Physics of Moscow State University)

SUBMITTED: July 26, 1961

33997
S/056/62/042/001/012/048
B104/B102

9,2574 (also 1055, 1163, 1144)

AUTHORS: Manenkov, A. A., Prokhorov, A. M.

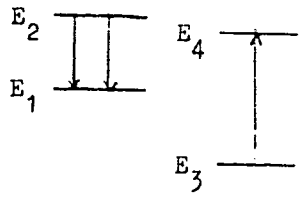
TITLE: Spin-lattice relaxation and cross-relaxation interactions in chromium corundum

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 1, 1962, 75-83

TEXT: The relaxation effects in the Cr^{3+} spectrum of Al_2O_3 single crystals were studied at helium temperatures. The relaxation times were measured with a superheterodyne radiospectroscope (9400 Mc/sec) by the technique of pulse saturation of paramagnetic resonance lines. This method (A. A. Manenkov et al., ZhETF, 41, 100, 1961) allows to separate the effects of spin-lattice relaxation from those of cross relaxation by saturation with pulses from 0.8 μsec to 1 sec duration. In the single crystals, 0.05, 0.1, 0.15, 0.4, and 0.65 % of Al^{3+} ions were replaced by Cr^{3+} ions. A four-level scheme of Cr^{3+} ions is assumed:

Card 1/3

Spin-lattice relaxation and...



and it is presupposed that no spin-lattice transitions take place between levels 1 and 3, 1 and 4, 2 and 3, and 2 and 4. If the transitions induced by an external field are less probable than spin-lattice and cross-relaxation transitions, the difference between the populations of the four levels can be given by

$$\Delta n_{12} = A \exp(\alpha_1 t) + B \exp(\alpha_2 t) + \Delta n_{12}^0,$$
$$\Delta n_{34} = A \exp(\alpha_1 t) - \frac{B}{m} \exp(\alpha_2 t) + \Delta n_{34}^0, \qquad (3).$$

$\alpha_1 = -1/T_1$, $\alpha_2 = -1/T_1 - 1/T_{12}$, $T_{12} = m/(1+\beta m)w$, where T_1 is the spin-

Card 2/3

Spin-lattice relaxation and...

lattice relaxation time, w is the probability of cross relaxation, and m = 1,2,3,... . Normally, $T_{12} \ll T_1$. Therefore, α_2 in (3) characterizes the spin-lattice relaxation. The experiments proved the existence of different relaxation times (Tables 1 and 2) in specimens with a Cr^{3+} concentration of 0.15 %. Relaxation curves which can be described by one exponential function were observed on specimens with Cr^{3+} concentrations of 0.05, 0.4, and 0.65 %. These curves correspond to spin-lattice relaxation. B. I. Kochalev (DAN SSSR, 131, 1053, 1960) and G. M. Zverev (ZhETF, 40, 1667, 1961) are mentioned. There are 5 figures, 4 tables, and 12 references: 5 Soviet and 7 non-Soviet. The four most recent references to English-language publications read as follows: J. H. Pace, D.F. Sampson, J. S. Thorp. Proc. Phys. Soc., 77, 257, 1961; B. Bolger, B. J. Robinson. Physica, 26, 133, 1960; R. A. Armstrong, A. Sabo, Canad. J. Phys., 38, 1304, 1960; J. E. Geusic, Phys. Rev., 118, 129, 1960.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: July 31, 1961

Card 3/3

S/056/62/042/005/036/050
B102/B138

AUTHORS: Manenkov, A. A., Prokhorov, A. M.

TITLE: The temperature dependence of the spin-lattice relaxation times

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 5, 1962, 1371-1374

TEXT: The temperature dependence of the spin-lattice relaxation times $T_1(T)$ in paramagnetic crystals is usually assumed as $T_1 \sim T^{-1}$, a law which is known to be violated in certain cases. The authors studied in detail the time dependence of the spin-lattice relaxation times for direct resonance energy exchange between the spin system and the lattice. Two special cases are considered: (1) A two-level system, in which equilibrium with thermal lattice vibrations is established according to the law $n_2-n_1=A\exp(-t/T_1)+(n_2-n_1)_{eq}$; the last term denotes the equilibrium difference of population corresponding to Boltzmann distribution. In this case the sought dependence is $T_1 \sim T^{-1}$. Only when level splitting is

Card 1/2

very high ($h\nu_{21} \gg kT$), T_1 is almost temperature independent. (2) A system of three levels: (a) $E_3 > E_2 > E_1$, $E_3 - E_2 \ll kT$, $E_2 - E_1 \gg kT$. If $h\nu_{21} \gg kT$, $n_3 - n_2 = A \exp(\alpha_1 t) + (n_3 - n_2)_{eq}$ with $T_1 = -1/\alpha_1 \approx 1/w_{31}$. w_{ik} is the probability of a transition $E_i \rightarrow E_k$. In this case the temperature dependence of the relaxation time is very weak and at $h\nu_{31} \gg kT$ it vanishes. (b) $E_3 - E_2 \gg kT$, $E_2 - E_1 \ll kT$. For $h\nu_{32} \gg kT$, for the $2 \rightleftarrows 1$ transition $n_2 - n_1 = A\exp(\alpha_1 t) + (n_2 - n_1)_{eq}$, $T_1 = -1/\alpha_1 \approx 1/w_{23}$, i. e. the temperature dependence is strong (exponential). The results indicate that the temperature dependence of the spin-lattice relaxation time depends on the relation between level splitting and kT.

ASSOCIATION:: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: December 26, 1961

ZVEREV, G.M.; PROKHOROV, A.M.

Electron paramagnetic resonance of rutile containing cobalt.
Zhur. eksp. i teor. fiz. 43 no.2:422-425 Ag '62. (MIRA 16:6)

1. Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.
(Paramagnetic resonance and relaxation) (Rutile) (Cobalt)

44230

S/056/62/043/006/023/067
B102/B104

24.2200

AUTHORS: Prokhorov, A.M., Fedorov, V.B.

TITLE: Antiferromagnetism of free radicals

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 6 (12), 1962, 2105-2109

TEXT: The chemical stability of the organic free radical αα-diphenyl β-picrylhydracyl (I) is investigated. The e.p.r. spectrum of this radical was measured at 42 Mc in the range 4.2 - 0.15°K. Below 1°K the integral intensity of the e.p.r. lines vanished; this is explained by a reconstruction of the energy spectrum of the system of magnetic moments of the unpaired electrons (each of the I molecules has one) and their transition into an ordered antiferromagnetic state due to exchange interaction. Three samples of I, crystallized from their benzoleic solution, were investigated: two triclinic single crystals and crystalline powder. They were cooled down to 0.15°K by means of adiabatic demagnetization of iron-ammonium alum. The constant magnetic field was modulated with a frequency of 0.5 cps in order to observe

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Antiferromagnetism of free ...

resonance absorption. The signal-to-noise ratio was ~100 when working with the large crystal (25 mg). The absorption line appearing on the oscilloscope screen was photographed. The integral line intensity s was determined as a product of line width ΔH and amplitude I. For the large crystal up to $T \approx 0.35^{\circ}K$, $s = const/(T+\theta)$, where $\theta = 0.35^{\circ}K$. Below that temperature s dropped faster than according to this law and it reached zero at $T \approx 0.18^{\circ}K$. The main change in s was observed between 0.2 and $0.3^{\circ}K$. The curve $s=s(1/T)$ did not depend on the orientation of the crystal with respect to the magnetic field, the position of its maximum was independent of T within 10% limits of error. As the imaginary part of the magnetic susceptibility had a single maximum at about $\nu_o = g\beta H/h$, $s = \chi''(\nu)d\nu$, and, according to Kramers-Kronig, the static susceptibility $\chi_o = \chi'(0) = \frac{2}{\pi}\int_0^{\infty}\frac{\chi''(\nu)d\nu}{\nu}$, or, if $\Delta\nu \ll \nu_o$:

$\chi_o = 2s/\pi\nu_o$. Therefore the relation $s=const/(T+\theta)$ expresses the Curie-Weiss law, θ being the paramagnetic Curie point. Since $\Delta\nu = 2\langle\Delta\nu^2\rangle/\nu_k$ where ν_k is proportional to the exchange integral

Card 2/3

(Rev.Mod.Phys., 25, 269, 1953) one can determine the magnitude of exchange interaction from the e.p.r. line width. There are 3 figures.

ASSOCIATION: Fizicheskiy institut im. P.N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P.N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: July 24, 1962

Card 3/3

PROKHOROV, A.M.

S/053/62/077/001/001/003
B117/B112

AUTHORS: Zverev, G. M., Karlov, N. V., Korniyenko, L. S., Manenkov, A. A., Prokhorov, A. M.

TITLE: Application of paramagnetic crystals in quantum electronics

PERIODICAL: Uspekhi fizicheskikh nauk, v. 77, no. 1, 1962, 61 - 108

TEXT: Western and Soviet studies during the period 1932 - 1962 concerning the progress in the application of paramagnetic crystals for building quantum devices are reviewed. In these devices, which are used in the fields of radio and optics, negative temperatures are produced by auxiliary radiation. The following problems are discussed: energy levels of paramagnetic ions in crystals; relaxation phenomena in paramagnetic crystals; (paramagnetic) quantum amplifiers of the radio range (paramagnetic resonance amplifier РПУ (RPU), paramagnetic progressive wave amplifier ПУБВ (PUBV)); quantum generators and amplifiers of the optical range (optical quantum generators with ruby and fluorite, quantum amplifiers, quantum counters). Finally, the great progress achieved in quantum electronics during the short time of its existence is pointed out:

Card 1/2

Application of paramagnetic...

establishment of highly accurate frequency standards for various purposes; development of low-noise paramagnetic amplifiers of the radio range and of optical generators having a high degree of coherence and high spectral radiation density. The quick progress of quantum electronics and its promising prospects, are the consequence of its development on the basis of already existing technology. Progress was first achieved in the radio range, and later in the optical range. At present work is in progress in developing the entire range, including the submillimeter- and distant infrared range. There are 27 figures and 134 references: 45 Soviet-bloc and 99 non-Soviet-bloc. The four most important English-language references are: J. R. Singer and S. Wang, Second International Conference on Quantum Electronics, Berkeley, 1961; W. G. Wagner and G. Birnbaum, Second International Conference on Quantum Electronics, Berkeley, 1961; R. W. Hellwarth, Phys. Rev. Lett., v. 6, 19 (1961); A. L. Schawlow, C. E. Devlin, Phys. Rev. Lett., v. 6, 96 (1961).

Card 2/2

KONYUKHOV, V.K., PASHININ, P.P., PROKHOROV, A.M., CHAYMOV-MALKOV, V.Y.

Quantum laser with traveling wave.

Report submitted to the Third Intl. Symp. on Quantum Electronics, Paris, France 11-15 Feb 1963

BARCHUKOV, A.I., PROKHOROV, A.M., SAVRANSKIY, V.V.

"Ammonia maser with disk resonator."

Report submitted to the Third Intl. Conf. on Quantum Electronics,
Paris, France 11-15 Feb 1963

AID Nr. 990-9 14 June

PROKHOROV, A.M.

TW MASER FOR AMPLIFICATION IN THE 3-cm BAND (USSR)

Karlova, Ye. K., N. V. Karlov, A. M. Prokhorov, and Ye. G. Solov'yev.
Pribory i tekhnika eksperimenta, no. 2, Mar-Apr 1963, 107-110.
S/120/63/000/002/025/041

Performance and construction details are described for a 3-cm traveling-wave maser which used a waveguide section containing two ruby rods attached along the base of a comb delay array on opposite sides of the teeth. The ruby had a Cr^{3+} concentration of about 0.07% and was 2 mm in diameter by 100 mm long; the red (isolating) ruby rod had a Cr^{3+} concentration of 1 to 2%. The external hf magnetic field was elliptically polarized in the plane of the comb, with its major axis normal to the traveling-wave line of propagation, in such a manner that at an eccentricity of 1.5 the energy density of the forward wave on one side of the comb array exceeded backward-wave density by 25 times. Measurement of energy density in the delay section was achieved by comparison of the EPR absorption line intensity in a DPPH sample, when the latter was located alternately in the feed-in and delay sections of the waveguide. The amplifier was

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AID Nr. 990-9 14 June

TW MASER FOR AMPLIFICATION [Cont'd] S/120/63/000/002/025/041

operated in a nitrogen-free He cryostat, type KP-09, which included magnetic shim disks to achieve a uniformity of external field of ± 1 gauss over the 100-mm working length. Amplifier performance, with a pumping wavelength of 1.2 cm and external field of 4300 gauss showed 10 db of clean gain at 4.2°K He temperature, and 21 db at 1.8°K. The bandwidth exceeded 20 Mc. Critical dimensions and alignments of the maser elements are discussed. Photographs of the delay element as well as the overall enclosed system are included. [SH]

Card 2/2

S/181/63/005/001/053/064
B104/B186

AUTHORS: Kaytmazov, S. D., and Prokhorov, A. M.

TITLE: E.p.r. spectra of HO_2, OH, DO_2 and OD radicals

PERIODICAL: Fizika tverdogo tela, v. 5, no. 1, 1963, 347-348

TEXT: The e.p.r. spectrum of frozen H_2O_2 (at 77°K) was studied at aqueous peroxide concentrations ranging from 3 to 0.01%. When changing the concentration, the spectra changed from a form which is characteristic of the HO_2 radical obtained by irradiation of 98% H_2O_2 to a form which is characteristic of the OH radical obtained by γ-irradiation of H_2O. The spectrum of the HO_2 radical differs from that of the DO_2 radical obtained at high D_2O_2 concentrations in the absence of the doublet at 12 oe. At low concentrations, the e.p.r. spectrum obtained on irradiation of D_2O_2, showed a triplet with a total splitting at 15 oe instead of the doublet at 45 oe. This indicates that the doublet (triplet) is formed by a hyperfine splitting

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E.p.r. spectra of HO_2, OH, RO_2...

S/181/63/005/001/053/064
B104/B186

on the proton (deuteron). Greater splitting of the OH radical (45 oe) spectrum as compared with that of the HO_2 radical (12 oe) suggests a greater spin density on the proton. There is 1 figure.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR, Moskva
(Physics Institute imeni P. N. Lebedev AS USSR, Moscow)

SUBMITTED: September 11, 1962

Fig. E.p.r. spectra of irradiated H_2O_2 solutions of different concentrations.

Legend: (1) 98%; (2) 3%; (3) 0.3%; (4) 0.1%; (5) 0.01%.

Card 2/3

PASHININ, P. P.; PROKHOROV, A. M.

Spin-lattice relaxation of Yb^{3+} in CdF_2. Fiz. tver. tela 5 no.1:359-360 Ja '63. (MIRA 16:1)

1. Fizicheskiy institut imeni Lebedeva AN SSSR, Moskva.

(Paramagnetic resonance and relaxation)
(Ytterbium) (Cadmium fluoride)

PROKHOROV, A.M.

AID Nr 975-13 23 May

EPR OF Tm^{2+} IN CaF_2 (USSR)

Pashinin, P. P., A. M. Prokhorov, and V. T. Udovenchik. Fizika tverdogo tela, v. 5, no. 4, Apr 1963, 1221-1222. S/181/63/005/004/045/047

Fluorite single crystals obtained by vertical zone melting in a vacuum were used to study the EPR of Tm^{2+} in CaF_2. The major portion of thulium entered the crystal lattice in the form of Tm^{3+} ions rather than Tm^{2+} ions; however, the Tm^{2+} ion concentration was increased by x-ray irradiation of the crystals. EPR was observed at 9250 Mc with temperatures of 4.2 and 60°K. The spectrum consisted of two superfine lines, separated by 228.8 ± 0.3 oe, whose position was independent of magnetic field direction. The superfine structure factor A for Tm^{169} was found to be $(367.5 \pm 0.5) \cdot 10^{-4} cm^{-1}$, and the g-factor to be 3.452 ± 0.002; these values are very close to the theoretical. By using the two factors, along with the spin-orbital coupling factor obtained by Kiss, the nuclear magnetic moment μ_I of Tm^{169} was found to be -0.193 ± 0.003. [BB]

Card 1/1

L 14525-63 EWA(k)/EWP(k)/BDS/3W2/EEC(b)-2/ES(t)-2/EWT(1) AFFTC/ESD-3/
ASD/RADC/APGC/AFWL/SSD Pf-4/Pi-4 GG/JHB/WG/IJP(C)/K/EH
ACCESSION NR: AP3005341 S/0181/63/005/008/2303/2305

AUTHOR: Kask, N. Ye.; Korniyenko, L. S.; Prokhorov, A. M.; Fakir, M. 84 83

TITLE: Electron paramagnetic resonance and spin-lattice relaxation of the Nd^{3+} impurity ion in the $CaWO_4$ single-crystal lattice

SOURCE: Fizika tverdogo tela, v. 5, no. 8, 1963, 2303-2305

TOPIC TAGS: electron paramagnetic resonance, Nd^{3+} ion, spin-lattice relaxation, calcium tungstate crystals, neodymium-doped calcium tungstate

ABSTRACT: A study of EPR spectra and spin-lattice relaxation of the Nd^{3+} ion in the $CaWO_4$ lattice has been carried out at liquid helium temperatures on the 3-cm band. The observed spectrum consisted of one intense line produced by even isotopes and two systems of eight components each produced by odd isotopes Nd^{145} and Nd^{143}. Angular dependence of the spectrum indicated a tetragonal symmetry of the crystal field surrounding the ion. Perpendicular and parallel g-factors and the superfine splitting factors for the odd isotopes were determined. It is shown that at temperatures above 6K the relaxation is determined by nonresonant two-phonon processes. Below that temperature, where single-phonon processes

Card 1/2

L 14525-63

ACCESSION NR: AP3005341

should predominate, observation of spin-lattice relaxation becomes difficult because of the phonon "narrow bottleneck" effect. When the thermal equilibrium of the spin system is weakly disturbed, as in the case of sufficiently small power of the saturation pulses, the "narrow bottleneck" effect is not observed, and the temperature variation of the spin-lattice relaxation can be determined. Orig. art. has: 1 figure and 3 formulas.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet im. M. V. Lomonosova (Moscow State University)

SUBMITTED: 02Feb63 DATE ACQ: 06Sep63 ENCL: 00

SUB CODE: PH NO REF SOV: 001 OTHER: 003

Card 2/2

L 14970-63 EWA(k)/EPF(n)-2/EWT(1)/EWP(q)/EWT(m)/BDS/T-2/3W2/EEC(b)-2/
ES(t)-2 AFFTC/ASD/ESD-3/RADC/APGC/AFWL/SSD Pu-4/Pi-4 GG/WH/WG/JHB/IJP(C)/K/EH
ACCESSION NR: AP3005342 S/0181/63/005/008/2306/2309

AUTHOR: Kask, N. Ye.; Korniyenko, L. S.; Mandel'shtam, T. S.; Prokhorov, A. M.

TITLE: Spin-lattice relaxation of the Ti^{3+} ion in corundum

SOURCE: Fizika tverdogo tela, v. 5, no. 8, 1963, 2306-2309

TOPIC TAGS: spin-lattice relaxation, single-phonon process, Ti^{3+} ion, titanium-doped corundum, electron paramagnetic resonance, pulse-saturation method

ABSTRACT: The spin-lattice relaxation of the Ti^{3+} ion in corundum has been studied by the pulse saturation method. Experiments were conducted using a superheterodyne spectroscope in the 3-cm band. A cryogenic cavity was employed which allowed rotation of the sample around two mutually perpendicular axes and thus permitted all possible orientations of the crystal axis with respect to the external magnetic field for crystals with axial symmetry. The temperature dependence of spin-lattice relaxation in the 1.7 to 3.5K range was determined. It was shown that below the 2K relaxation is determined by single-phonon processes and the relaxation time varies as e exp(d/kT) at d = (30 ± 3) cm^{-1}. The dependence of relaxation time in single-phonon processes on the external magnetic field determined on the basis of other relationships and the value of the experimentally

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L 14970-63
ACCESSION NR: AP3005342

obtained splitting factor are in good qualitative and quantitative agreement with experimental results. "The authors thank G. M. Zverev for a fruitful discussion of results of the present work." Orig. art. has: 3 figures and 2 formulas.

ASSOCIATION: Moskovskiy gosudarstvenny*y universitet im. M. V. Lomonosova (Moscow State University)

SUBMITTED: 02Apr63 DATE ACQ: 06Sep63 ENCL: 00

SUB CODE: PH NO REF SOV: 008 OTHER: 001

Card 2/2

PASHININ, P.P.; PROKHOROV, A.M.

Spin-lattice relaxation of the Fe^{3+} ion in $K_3(Co,Fe)(CN)_6$. Fiz. tver tela 5 no.9:2722-2723 S '63. (MIRA 16:10)

1. Fizicheskiy institut im. P.N.Lebedeva AN SSSR, Moskva.

KARLOVA, Ye.K.; KARLOV, N.V.; PROKHOROV, A.M.; SOLOV'YEV, Ye.G.

Traveling-wave quantum amplifiers in the three-centimeter band. Prib. i tekh. eksp. 8 no.2:107-110 Mr-Ap '63. (MIRA 16:4)

1. Fizicheskiy institut AN SSSR.
(Masers)

BARCHUKOV, A.I.; PROKHOROV, A.M.; SAVRANSKIY, V.V.

Ammonia maser with disc resonator. Radiotekh. i elektron. 8 no.3:438-439 Mr '63. (MIRA 16:3)

(Masers)

KARLOV, N.V.; PROKHOROV, A.M.

Multicavity quantum amplifiers. Radiotekh. i elektron. 8 no.3:453-456 Mr '63. (MIRA 16:3)

1. Fizicheskiy institut im. P.N.Lebedeva AN SSSR.
(Masers) (Amplifiers (Electronics))

L 10372-63 EWA(k)/EWT(l)/BDS/FBD/T-2/JW2/EEC(b)-2/ES(t)-2--AFFTC/ASD/ESD-3/RADC/APGC/AFWL--Pl-4/Po-4--IJP(C)/WG/K/JHB/EH

ACCESSION NR: AP3001007 S/0109/63/008/006/1073/1074

AUTHOR: Prokhorov, A. M. 15 78

TITLE: Generation by a laser during instantaneous Q-switching

SOURCE: Radiotekhnika i elektronika, v. 8, no. 6, 1963, 1073-1074

TOPIC TAGS: Q-spoiling laser, high-power pulse

ABSTRACT: A theoretical study has been carried out to determine the conditions under which maximum power output is obtained from a laser operating in the Q-switching mode and employing either Kerr cells or mechanical devices. Equations describing these conditions are set up in terms of energy density in the crystal, negative absorption factor, emission frequency, speed of light in the crystal, and the difference in the density of particles at upper and lower energy levels. The maximum energy density is determined, peak power is derived, and pulse duration is calculated. Numerical results are derived for a ruby rod with a length of 5 cm, a cross-sectional area of 1 cm sup 2, and an ion density of 2 x 10 sup 19 cm sup -3. At full population

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L 10372-63
ACCESSION NR: AP3001007

inversion the negative absorption factor is about 0.4 cm sup -1. Under the assumption that the ratio of the negative to the equivalent absorption factor (which includes all losses) is 0.3, the peak power emission including all losses is about 10 sup 10 w, the time at which energy density reaches half the maximum value is 5 x 10 sup -9 sec, and the time during which the energy density remains above half the maximum value is 2 x 10 sup -9 sec. In this last period the energy expended is about 11 joules. Orig. art. has: 11 formulas.

ASSOCIATION: none

SUBMITTED: 21Dec62 DATE ACQ: 01Jul63 ENCL: 00

SUB CODE: 00 NO REF SOV: 002 OTHER: 002

ch/ur
Card 2/2

L 18380-63 EWA(k)/EWT(l)/EWT(m)/EWP(q)/FBD/BDS/T-2/EEC(b)-2/ES(t)-2
AFFTC/ASD/ESD-3/RADC/APGC/AFWL/LJP(C)/3W2 JD/JHB/WG/K
ACCESSION NR: AP3006472 S/0109/63/008/009/1641/1642

AUTHOR: Barchukov, A. I.; Prokhorov, A. M.; Savranskiy, V. V. 76

TITLE: Biharmonic regime of an ammonia-beam maser 25

SOURCE: Radiotekhnika i elektronika, v. 8, no. 9, 1963, 1641-1642 27

TOPIC TAGS: ammonia-beam maser, beam maser, maser

ABSTRACT: Investigations of an ammonia-beam maser (line I = 3, K = 3, λ = 1.25 cm) using a disk cavity have shown that under certain conditions there is a simultaneous generation of a number of frequencies with a frequency difference from several hundred cps to several kc, depending on test conditions. For instance, by applying a constant electric field of the order of 30 v/cm to the cavity disks a difference of 5.4 kc is attained; with a further voltage increase the oscillation is disrupted. Under ordinary conditions the beat frequency was about 3.8 cps. The investigations have demonstrated the existence of at least two types of oscillations in the region of the spectral transition line, separated by about 20 Mc, with a Q-factor of about 7000 to 8000 for one type and of less than 1000 for the other. The existence of the biharmonic

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L 18380-63
ACCESSION NR: AP3006472

regime is explained by the nonuniform broadening of the transition line investigated. This explanation is also confirmed by the fact that the beat frequency increases with an increase in nonuniform broadening. Orig. art. has: 2 figures.

ASSOCIATION: none

SUBMITTED: 24Jan63 DATE ACQ: 30Sep63 ENCL: 00

SUB CODE: GE, SD NO REF SOV: 001 OTHER: 001

Card 2/2

L 15701-63 EWA(k)/EWT(1)/EWP(q)/EWT(m)/BDS/T-2/3W2/EEC(b)-2/ES(t)-2
AFFTC/ASD/ESD-3/RADC/APGC IJP(C)/K/WG/JD/JHB/EH
ACCESSION NR: AP3006473 S/0109/63/008/009/1642/1643

AUTHOR: Pimenov, Yu. P.; Prokhorov, A. M.

TITLE: Quantum paramagnetic amplifier based on Cr^{3+} ions in the rutile lattice

SOURCE: Radiotekhnika i elektronika, v. 8, no. 9, 1963, 1642-1643

TOPIC TAGS: quantum paramagnetic amplifier, paramagnetic amplifier, quantum amplifier, Cr^{3+} ion, ion, rutile, titanium dioxide, amplifier

ABSTRACT: Single-crystal rutile (TiO_2) with a 0.1% admixture of paramagnetic Cr^{3+} ions was employed in a cavity-tuned amplifier operating on the 10-cm wavelength at a temperature of 4.2K. The trigonal axis of the crystal was parallel to the static magnetic field, so that the energy levels of two nonequivalent Cr^{3+} ion systems coincided. The static magnetic field was formed by an electromagnet using a superconductive niobium winding. A junction with magnetic quantum numbers $M = \pm 1/2$ was used between the lower layers for amplification. In the cavity the hf magnetic field of the signal was perpendicular to the external magnetic field and to the trigonal crystal axis. With an amplifier voltage gain of 19 db, the recovery time for the gain to settle at the 16-db

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L 15701-63
ACCESSION NR: AP3006473

level following the removal of the saturating signal was 1.2 msec. Spin-lattice relaxation time was measured by the pulse saturation of the line of the paramagnetic resonance junction used for signal amplification. The saturation pulses had a duration of 1 msec at a repetition rate of 200 cps. The relaxation curve is described by one exponential. Spin-lattice relaxation time is 0.5 msec. "The authors thank R. P. Bashuk and A. S. Bebchuk for the production of single-crystal rutile, and A. A. Manenkov for his assistance in the work." Orig. art. has: 1 formula.

ASSOCIATION: none

SUBMITTED: 16Jan63 DATE ACQ: 30Sep63 ENCL: 00

SUB CODE: SD, GE NO REF SOV: 002 OTHER: 000

Card 2/2

PROKHOROV, A.M.

Amplification properties of a dielectric filament. Opt. i spektr. 14 no.1:73-77 Ja '63. (MIRA 16:5)
(Dielectric amplifiers)

L 1786-63 EPF(c)/EWT(m)/BDS Pr-4 RM/WW

ACCESSION NR: AP3005845 S/0051/63/015/002/0221/0225

Author: Murina, T.M.; Prokhorov, A.M. 57

TITLE: Investigation of the methyl chloride molecule by means of a beam spectroscope with a disk resonator.

SOURCE: Optika i spektroskopiya, v.15, no.2, 1963, 221-225

TOPIC TAGS: microwave spectrum, rotational transition, hyperfine structure, beam spectroscopy, methyl chloride

ABSTRACT: The present study of CH_3Cl was one of the proposed series of investigations of the hyperfine structure of molecules by means of a molecular beam (microwave) spectroscope with a disk resonator with Stark modulation (T.M.Murina, Radiotekhnika i elektronika, 6, 1586, 1961). Specifically, the authors investigated the magnetic hyperfine structure of the CH_3Cl molecule associated with the rotational $J = 0 \rightarrow J = 1$ transitions. As a result of quadrupole splitting of the rotational levels there should be observed three transitions, but in the present experiments only two were observed: $F_1 = 3/2 \rightarrow F_1 + 1 = 5/2$ (frequency 26598.59 Mc) and $F_1 = 3/2 \rightarrow F_1 - 1 = 1/2$ (frequency 26604.57 Mc). The calculated and experimental

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L 17786-63
ACCESSION NR: AP3005845

spectra are reproduced. The agreement is satisfactory, as is that between the calculated and experimental values of the hyperfine magnetic structure constant (IJ coupling constant) A for the hydrogen nuclei (A = -7.5 ± 0.5 kc). (I is the nuclear spin and J is the molecular angular momentum.) Orig.art.has: 4 formulas, 4 figures and 2 tables.

ASSOCIATION: none

SUBMITTED: 20Dec62 DATE ACQ: 06Sep63 ENCL: 00

SUB CODE: PH NO REF SOV: 001 OTHER: 003

Card 2/2

YEMEL'YANOVA, Ye.N.; KARLOV, N.V.; MANENKOV, A.A.; MILYAYEV, V.A.; PROKHOROV, A.M.; SMIRNOV, S.P.; SHIRKOV, A.V.

Electron paramagnetic resonance spectrum and spin-lattice relaxation of chromium and iron ions in zinc tungstate single crystals. Zhur. eksp. i teor. fiz. 44 no.3:868-869 Mr '63. (MIRA 16:3)

1. Fizicheskiy institut imeni P.N.Lebedeva AN SSSR.
(Paramagnetic resonance and relaxation) (Zinc tungstate crystals)
(Ions)

L 17631-63 EPR/EPF(c)/EWT(1)/EWT(m)/BDS/ S/056/63/044/003/052/053
EEC(b)-2 AFFTC/ASD/ESD-3/RADC/AFWL/IJP(C) Ps-4/Pr-4/Pi-4 CG/RM/WW/JW/JFW

83

AUTHOR: Prokhorov, A. M. and Fedorov, V. B.

TITLE: Supplement to the paper "The antiferromagnetism of free radicals" /1/

PERIODICAL: Zhurnal eksperimental'noy i tekhnicheskoy fiziki, v. 44, no 3, 1963, 1125-1126

TEXT: The authors state the relation existing between the Curie temperature and the width of the paramagnetic resonance absorption line, which agrees with the experimental data in the paper mentioned in the title (Ref. 1: Prokhorov and Fedorov, ZhETF, 43, 2105, 1962) and which concerns the $\alpha\alpha$ - diphenil-β - picril-hydrazil at 1 and 77°K. Further discussion of the changes in the absorption width and Curie temperature as function of temperature and the study of the corresponding crystal lattice indicate that the $\alpha\alpha$-dyphenil-β-picril-hydrazil represents at and below helium temperature a system of magnetic moments closely resembling an assembly of parallel linear chains. There is 1 figure.

SUBMITTED: December 24, 1962

Card 1/1

PROKHOROV, A.M.

AID Nr. 984-8 6 June

GENERATION OF MILLIMETER WAVES IN OPTICALLY PUMPED RUBY (USSR)

Zverev, G. M., A. M. Prokhorov, and A. K. Shevchenko. Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 44, no. 4, Apr 1963, 1415-1418.
S/056/63/044/004/042/044

Experiments have been conducted using a ruby laser at 77°K to pump a three-level ruby millimeter-wave ($35\text{-}50 \cdot 10^9$ cps) generator operating at the same temperature. Emission from the nitrogen-cooled ruby laser passed through a system of mirrors and a lens onto the end of a nitrogen-cooled ruby which served as a millimeter-band resonator and whose c-axis was perpendicular to the external magnetic field. Emission from the generator ruby was detected by a reflector-type superheterodyne radio spectroscope which also controlled

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AID Nr. 984-8 6 June

GENERATION OF MILLIMETER WAVES [Cont'd] S/056/63/044/004/042/044

the required magnetic field. The detected output, along with the photomultiplier-monitored laser pulse signal, was displayed on the screen of a pulse oscillograph. The generated millimeter-band power output was ~ 10^{-5} w. The emission had the multiple-spike form observed in rf-pumped paramagnetic generators. It was calculated that the maximum power ideally obtainable in the sample used (0.05% chromium ion concentration) is 1.7 mw in a pulse with a duration of ~ 150 μsec.

[BB]

Card 2/2

L 10725-63 EWA(k)/EWT(1)/FBD/T-2/BDS/3W2/EEC(b)-2/ES(t)-2 AFFTC/ASD/ESD-3/RADC/APGC/AFWL Pl-4/Po-4 LJP(C)/WG/K/JHB/EH

ACCESSION NR: AP3003155 S/0056/63/044/006/2180/2182 85

AUTHOR: Askar'yan, G. A.; Prokhorov, A. M.; Chanturiya, G. F.; Shipulo, G. P. 81

TITLE: Laser beam in liquid 35

SOURCE: Zhurnal eksper. i teor. fiziki, v. 44, no. 6, 1963, 2180-2182

TOPIC TAGS: laser effects, photohydraulic effects, laser beam in liquid

ABSTRACT: An experimental study of the effects of focused and unfocused laser beams on liquids had been carried out. A ruby laser with a beam pulse duration of approximately 1 microsec was used. Bubble formation due to focused and unfocused beams was observed and photographed in water. In ordinary tap water the formation of bubbles ceased with decreased beam intensity, while in gassed water no such decrease was observed. Special control experiments showed that light scattering

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L 10725-63

ACCESSION NR: AP3003155

3

takes place on the bubbles and not on inhomogeneities in the liquid. The size of the bubbles and the light scattering parameters were calculated. An oscillographic study of the scattering process showed that scattering changes in time and that the scattering centers increase the scattering effect. Photohydraulic effects occurring during focusing of the beam near or on the surface of a plate immersed in liquid were noted. Explosive local boiling, downward and upward motion of the plate, changes in the nature of the orifice drilled in the plate by the beam, rupturing of the vessel by shock waves, and ejection of liquid from the impact area were also observed. Increases in the absorption of light by the water, brought about through addition of copper sulfate, led to a sharp increase in the intensity of photohydraulic effects. The height of the ejected stream reached one meter, and in some cases almost all the water was ejected from the vessel. "In conclusion the authors express their gratitude to V. S. Zuyev and V. K. Konyukhov for participation in the preliminary experiments with gassed liquids conducted in the summer of 1962." Orig. art. has: 2 formulas.

Card 2/3 Physics Inst Academy of Sci

KONYUKOV, V.K.; KULEVSKIY, L.A.; PROKHOROV, A.M.

Ruby-operated laser with a generation length of ~10 msec.
Zhur. eksp. i teor. fiz. 45 no.4:857-862 O '63. (MIRA 16:11)

1. Fizicheskiy institut imeni P.N.Lebedeva AN SSSR.

Prokhorov, A.M.

AID Nr. 971-13 20 May

STUDY OF RUBY LASER AT LIQUID NITROGEN TEMPERATURE (USSR)

Konyukhov, V. K., L. A. Kulevskiy, and A. M. Prokhorov. IN: Akademiya nauk SSSR. Doklady, v. 149, no. 3, 21 Mar 1963, 571-572.

S/020/63/149/003/012/028

Spectral components of ruby laser emission corresponding to laser transitions to the $\pm 1/2$ and $\pm 3/2$ components of the ground state have been studied at 77.4°K. A light-pink ruby sample 6 mm in diameter and 60 mm long was used, with one end silver-coated and the other uncoated. The laser beam was passed through a Fabry-Perot interferometer with a 0.20-cm air gap into a long-focus camera, where it was either photographed on red-sensitive film or separated into the two components by a mask. In the latter case each component was detected separately by a photomultiplier, and the two signals were registered by a dual-beam oscillograph. Near the laser threshold only the $\pm 3/2$ (short-wave) component was observed, the other appearing at higher pumping energies. The frequency difference of the two components, calculated from the interference pattern (0.36 ± 0.03) cm^{-1} agrees, within the experimental error, with a value calculated from the splitting of the Cr^{3+} ground state in the Al_2O_3 lattice (the ground state being determined by EPR methods). It was determined

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AID Nr. 971-13 20 May

STUDY OF RUBY [Cont'd] S/020/63/149/003/012/028

that the components carry different fractions of the output energy: near the threshold the short-wave component carries most of the energy, while the long-wave component increases to 21 ± 1% of the short-wave component considerably above the threshold. The time variation of the two components was shown to be quite dissimilar. The short-wave component was generated in 0.5 to 0.8 μsec, and its duration increased with increased pumping energy; the long-wave component was generated in 0.1 to 0.15 μ sec, and its duration decreased with increased pumping energy. [BB]

Card 2/2

ACCESSION NR: AP4011756 S/0181/64/006/001/0193/0199

AUTHORS: Gasanov, E. M.; Prokhorov, A. M.; Fedorov, V. B.

TITLE: Paramagnetic relaxation in systems with strong exchange interaction at low temperatures

SOURCE: Fizika tverdogo tela, v. 6, no. 1, 1964, 193-199

TOPIC TAGS: paramagnetic relaxation, exchange interaction, low temperature, Alpha Alpha diphenyl Beta picrylhydrazine, magnetic ordering, absorption line, integral intensity, Zeeman subsystem, exchange subsystem

ABSTRACT: In experiments on electron paramagnetic resonance in the free organic radical α,α-diphenyl-β-picrylhydrazine at 42 Mc the authors observed, along with an increase in absorption line width, an increase in relaxation time between Zeeman and exchange subsystems when the temperature was reduced from 77 to 1.5K. According to theory and some experiments, at extremely cold temperatures the relaxation time should become shorter when the width of the line is increased. The discrepancy between experiment and theory is apparently due to the difference between properties of the spin systems in the organic crystal studied and those of a

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ACCESSION NR: AP4011756

purely paramagnetic system. This difference appears in local magnetic ordering of spins at low temperatures, which is associated with increases in the value $I/kT \to 1$ but which is not substantial in experiments at frequencies on the order of 10,000 Mc with a large external magnetic field. This local ordering is indicated by a decrease in the integral intensity of the absorption line at temperatures of about 2.0K. Near magnetic ordering indicates the introduction of a correlation between the exchange interaction of various spin pairs, and, consequently, diminishes (for constant intensity) characterizing an exchange constriction of the absorption line. An increase in relaxation time means an increase in the characteristic frequency of the exchange subsystem in which the relaxation process occurs; given magnetic ordering, which changes the energy spectrum of the exchange system, this increase in frequency may be considered probable. Orig. art. has: 2 figures and 15 formulas.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR, Moscow (Physics Institute AN SSSR)

SUBMITTED: 22Jul63 DATE ACQ: 14Feb64 ENCL: 00

SUB CODE: PH NO REF SOV: 003 OTHER: 011

Card 2/2

ACCESSION NR: AP4018375 S/0120/64/000/001/0106/0109

AUTHOR: Martirosyan, R. M.; Prokhorov, A. M.

TITLE: Quantum paramagnetic amplifier with coupled resonators for decimeter band

SOURCE: Pribory* i tekhnika eksperimenta, no. 1, 1964, 106-109

TOPIC TAGS: amplifier, quantum amplifier, paramagnetic amplifier, two resonator quantum amplifier, decimeter band quantum amplifier, radioastronomy

ABSTRACT: A superconductive-winding solenoid provides a highly stable constant magnetic field (about 2,000 oerst.) and reduces the weight of the amplifier to 10 kg. Both the active (Cr^{3+} in Al_2O_3) and the passive resonators are of a hollow-microstrip type. Experimentally determined characteristics of the above design have shown that the product of gain and bandwidth is 2.5 times higher than that of a one-resonator amplifier. The amplifier is intended for

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ACCESSION NR: AP4018375

radioastronomical application, particularly in studies of monochromatic radiation of galactic hydrogen. Priority is claimed with respect to a similar amplifier described by K. L. Kyhl, et al., in Proc. IRE, 1962, 50, 7, 1608. Orig. art. has: 5 figures, 1 formula, and 1 table.

ASSOCIATION: Fizicheskiy institut AN SSSR (Institute of Physics, AN SSSR)

SUBMITTED: 15Nov62 DATE ACQ: 18Mar64 ENCL: 00

SUB CODE: PH NO REF SOV: 003 OTHER: 003

Card 2/2

L 17116-65 EED-2/EEO-2/EWT(d) Pj-4/Pn-4 SSD/ASD(a)-5/AFWL/BSD/AFETR/
AFTC(p)/RAEM(a)/RAEM(c)/RAEM(i)/ESD(gs)/ESD(t) JHB
ACCESSION NR: AP5000447 S/0109/64/009/012/2088/2093

AUTHOR: Karlov, N. V.; Prokhorov, A. M.

TITLE: On the critical sensitivity of receivers of electromagnetic radiation

SOURCE: Radiotekhnika i elektronika, v. 9, no. 12, 1964, 2088-2093

TOPIC TAGS: submillimeter receiver, optical frequency receiver, superheterodyne receiver, receiver sensitivity, critical sensitivity, maser, laser

ABSTRACT: The limiting sensitivity of receivers is considered analytically for all frequencies in general, and for the submillimeter and optical frequencies in particular. N independent modes are assumed in the receiver. Special distinction is made of the case of linear reception of a coherent signal retaining phase information, where the sensitivity limit is imposed by the amplitude-phase ambiguity. Expressions are given showing that in the case of maser receivers at high pumping levels, the limiting sensitivity of coherent signal receivers does not depend upon frequency. The authors also consider the sensitivity of coherent receivers as a function of the number of modes. If the input system is designed to limit the propagation of a monochromatic signal to a single mode while noise is present in all the modes, the sensitivity of the receiver can be sharply improved. Orig. art. has: 23 formulas.

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L 17116-65
ACCESSION NR: AP5000447

ASSOCIATION: Fizicheskiy Institut imeni P. N. Lebedeva AN SSSR (Institute of Physics, AN SSSR)

SUBMITTED: 19Feb64 ENCL: 00 SUB CODE: EC

NO REF SOV: 005 OTHER: 002 ATD PRESS: 3148

Card 2/2

L 7807-65 EWT(d)/EWT(l)/EEC(b)-2/EWA(h) Pn-4/Pac-4/Peb/Pi-4/Pj-4 AFWL/
ASD(a)-5/SSD/AFETR/RAEM(a)/ESD(c)/ESD(gs)
ACCESSION NR: AP5000448 S/0109/64/009/012/2094/2098

AUTHOR: Martirosyan, R. M.; Prokhorov, A. M.

TITLE: Quantum paramagnetic amplifier with active resonators at a 21-cm wave

SOURCE: Radiotekhnika i elektronika, v. 9, no. 12, 1964, 2094-2098

TOPIC TAGS: quantum paramagnetic amplifier, microwave amplifier

ABSTRACT: Experimental data on the characteristics of a quantum paramagnetic amplifier (QPA) operated at 1,420 Mc and having two coupled active paramagnetic-containing resonators is supplied. Two quarter-wave microstrip resonators mounted in a square 17 x 17-mm waveguide were coupled through their end capacitance (design sketch supplied). A 2,000-oer magnetic field was obtained from a superconductive Nb solenoid. Cr^{3+} of 0.04% concentration was used in an Al_2O_3 lattice. As compared with the two-resonator system with an input passive circuit, the QPA has a much higher gain x bandwidth product; the QPA also has

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L 17807-65

ACCESSION NR: AP5000448

the advantage in a more stable gain. The QPA characteristics well agree with theoretical calculations. "The authors wish to thank I. B. Matrosov for his help in experimentation." Orig. art. has: 3 figures, 1 formula, and 1 table.

ASSOCIATION: none

SUBMITTED: 19Aug63 ENCL: 00

SUB CODE: EC NO REF SOV: 004 OTHER: 001

Card 2/2

ACCESSION NR: AP4011484 S/0051/64/016/001/0058/0062

AUTHOR: Gvaladze,T.V.; Konyukhov,V.K.; Prokhorov,A.M.; Khaimov-Mal'kov,V.Ya.; Shipule,G.P.

TITLE: R-absorption lines of ruby

SOURCE: Optika i spektroskopiya, v.16, no.1, 1964, 58-62

TOPIC TAGS: R absorption, R levels, R line luminescence, ruby, optical pumping, lasers, luminescence lifetime

ABSTRACT: Although there have been many investigations of the luminescence of R-lines of ruby, hitherto there have been no detailed studies of the absorption in the region of these lines. Study of the absorption can yield information on the frequency variation of the absorption coefficient, $\alpha(\nu)$, and the temperature dependence of $\int\alpha(\nu)d\nu$, which is indicative of the temperature variation of the matrix element of the dipole moment. In the present work the R-line absorption of ruby (Cr_2O_3 concentration 0.04% by weight) was investigated at 16, 60, and 95°C. The measurements were performed with the aid of a DFS-13 diffraction grating spectrograph (dispersion 4 Å/mm) with photographic recording and a DFS-8 grating spectrograph (6 Å/mm) with

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ACC.NR: AP4011484

photoelectric recording. The values of $\alpha(\nu)$ for the R_1 and R_2 lines are 0.315 and 0.24, respectively, and are virtually temperature independent in the 16 to 95°C temperature range. Reabsorption was found to be negligible under the given conditions. The luminescence lifetimes of the R_1 and R_2 lines, calculated on the basis of the experimental data, are of the order of 2.9 and 4.2 microsec, respectively. The relative intensities of the R luminescence lines are proportional to the populations of the respective levels and inversely proportional to $\tau(R)$. The R_2/R_1 intensity ratio for T = 93°K, derived from the present data, is about 0.43, which is in exact agreement with the experimental value of N.A.Tolstoy, Liu Shun-fu, and M.E.Lapidus (Opt.i spektro.,13, 242, 1962). Orig.art.has: 14 formulas, 2 tables, and 1 figure.

ASSOCIATION: none

SUBMITTED: 18Mar63 DATE ACQ: 14Feb64 ENCL: 00

SUB CODE: PH NR REF SOV: 003 OTHER: 005

Card 2/2

ACCESSION NR: AP4012567 S/0056/64/046/001/0386/0389

AUTHORS: Kaminskiy, A. A.; Korniyenko, L. S.; Makarenko, L. V.; Prokhorov, A. M.; Fursikov, M. M.

TITLE: Investigation of stimulated emission of Nd^{3+} in calcium fluorite at room temperature

SOURCE: Zhurnal eksper. i teoret. fiz., v. 46, no. 1, 1964, 386-389

TOPIC TAGS: stimulated emission, molecular generator, maser, calcium fluorite, neodymium impurity, neodymium doping, emission wavelength, emission time dependence, radiation structure, fine structure component.

ABSTRACT: The only fluorite doped with Nd^{3+} previously found to exhibit stimulated emission at room temperature was SrF_2 (L. F. Johnson, J. Appl. Phys., v. 34, 897, 1963). The authors report tests of

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ACCESSION NR: AP4012567

crystals grown from the melt in a fluoriding atmosphere by lowering the crucible. Emission was observed in crystals with neodymium oxide concentrations 0.3 and 1.5%, the approximate wavelength being 1.047 micron. The system was excited by absorption of light from a flash system at 14,000 cm^{-1} above ground level. Emission corresponded to the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition. The illuminating system consisted of an elliptical system with the crystal in one focus and the flash lamp (80-mm glow column) in the other. The time dependence of the radiation was determined with a photomultiplier and oscilloscope. The structure of the radiation was determined with a spectrograph having a 600 line/mm grating. For the crystal with 0.3% neodymium oxide the emission line width was approximately 3 Å (4 fine structure components), increasing to 5 Å (12 components) for the 1.5% crystal. "The authors are grateful to V. V. Osiko and Yu. K. Voronko for supplying the fluorite crystals and for fruitful discussions." Orig. art. has: 2 figures.

Card 2/3

ACCESSION NR: AP4012567

ASSOCIATION: Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta (Nuclear Physics Institute, Moscow State University)

SUBMITTED: 28Oct63 DATE ACQ: 26Feb64 ENCL: 00

SUB CODE: PH NO REF SOV: 001 OTHER: 001

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ACCESSION NR: AP4025942 S/0056/64/046/003/1090/1097

AUTHORS: Bunkin, F. V.; Prokhorov, A. M.

TITLE: Excitation and ionization of atoms in a strong radiation field

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 46, no. 3, 1964, 1090-1097

TOPIC TAGS: radiation field, strong radiation field, laser radiation field, hydrogen atom excitation, hydrogen atom ionization, hydrogenlike atom quantum transition, monochromatic strong field, circularly polarized strong field, quasiclassical approximation, effective ionizing field

ABSTRACT: It is shown first that the electric field produced by a laser (~3 x 10^8 V/cm for a beam with 10 μ diameter) approaches the intensity of the interatomic field (~5 x 10^9 eV/cm for the hydrogen

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atom in the ground state). It is then shown that at such field intensities the quantum transitions that follow from ordinary perturbation theory will no longer be observed, and if the time of interaction between the field and the atom is sufficiently long the latter is most likely to be ionized rather than excited to a bound state, even if the field quantum is much lower than the ionization potential. The general character of the quantum transitions in hydrogen-like atoms under the influence of a strong circularly-polarized monochromatic field is analyzed in the quasiclassical approximation. In view of the similar results produced by a strong radiation field and a strong dc field (ionization), the concept of effective ionizing field is introduced and evaluated for strong circularly-polarized monochromatic radiation. Orig. art. has: 22 formulas.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR (Physics Institute, AN SSSR)

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Card

L 20292-65 EWA(k)/EWT(l)/EEC(k)-2/T/EEC(b)-2/EWP(k)/EWA(m)-2 Po-4/P1-4/P1-4
IJP(c)/ASD(a)-5/AFWL/SSD/AS(mp)-2/AFETR/RAEM(c)/RAEM(i)/ESD(gs)/ESD(t) JHB/WG
ACCESSION NR: AP4042550 S/0056/64/046/006/1937/1952

AUTHOR: Prokhorov, A. M.; Fedorov, V. B.

TITLE: Paramagnetic relaxation in $K_3(Fe, Co)(CN)_6$ at temperatures 0.1-4.2K

SOURCE: Zh. eksper. i teor. fiz., v. 46, no. 6, 1964, 1937-1952

TOPIC TAGS: paramagnetic relaxation, spin lattice relaxation, crystal lattice, electron paramagnetic resonance, low temperature research

ABSTRACT: In view of the increasing applications of paramagnetic crystals and the increasing practical and theoretical interest in paramagnetic relaxation at low temperatures, the authors measure

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Fe^{3+} in a $K_3Co(CN)_6$ lattice at a temperature T = 0.08--4.2K. Unlike experiments made by others at ~10^4 Mcs, the results obtained contradict the paramagnetic relaxation theory of Van Vleck and Kronig. It is shown that the observed singularities of paramagnetic relaxation in ferrocyanide at low temperatures are due to weak exchange interactions in the system of paramagnetic ions of iron. These interactions do not play an important role in experiments with large magnetic fields at high frequencies. The already published energy spectrum of the ion pairs in the cyanide of iron is used to develop, under certain assumptions, a mechanism for the relaxation process, which explains qualitatively the experimentally observed facts. A

facts, and also give satisfactory values for the probabilities of

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nonradiative transitions of the ion pairs. A decisive role is indicated for ion pairs in the transfer of energy from the iron ions in the lattice at low temperatures in low-frequency experiments. The authors thank K. K. Svidzinskiy for a discussion and valuable re-